Dateline Los Alamos

Assessing the Global Hydrogen Budget

A recent study—published in *Nature* by Thom Rahn, a Frederick Reines Postdoctoral Fellow, and colleagues—indicates that molecular hydrogen in the atmosphere tends to enrich deuterium in the stratosphere, home to Earth's ozone layer. In this study, Rahn collaborated with researchers from the California Institute of Technology, the University of California at Berkeley, the University of California at Irvine, and the National Center for Atmospheric Research. Their finding has ramifications for the use of hydrogen fuel cells as an alternative energy source to fossil fuels.

Extremely small concentrations of deuterium are known to exist throughout the universe. However, deuterium levels in the stratosphere are nearly one and a half times higher than they are in seawater—Earth's most abundant reservoir of elemental hydrogen and hence an excellent reference point.

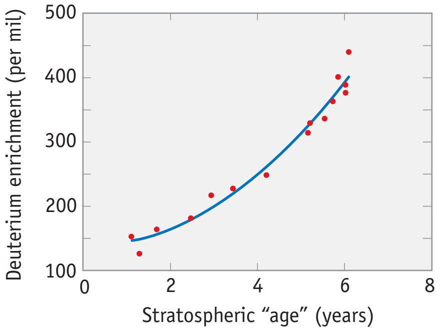
Rahn and colleagues have shown that this enrichment results from isotopic-mass-dependent reactions related to the photochemical oxidation of methane. Methane has both natural and manmade sources and is a major contributor to atmospheric molecular hydrogen. Quantifying its contribution to the global hydrogen budget is essential to assess the environmental benefits and risks of using hydrogen fuel cells on a large scale.

A hydrogen-based economy should reduce pollutants like nitrogen oxides, the precursors of urban smog, and particulates that result from the combustion of fossil fuels. Such reductions would improve urban air quality and enhance human health. However, the unavoidable escape of molecular hydrogen from the production, storage, and transfer facilities associated with a fuel-cell infrastructure would increase hydrogen concentrations in the atmosphere.

Since hydrogen produces water in the stratosphere, there is concern that its buildup could increase global warming and catalyze chemical reactions that would further deplete Earth's ozone layer near the poles. In the lower troposphere, hydrogen buildup could also reduce the abundance of hydroxyl radicals—chemicals that help scrub greenhouse gases such as methane from the atmosphere.

Developing models to study the hydrogen budget will allow scientists to address these concerns and avoid another chlorofluorocarbon blunder. "Our study gives us a tool in looking ahead at potential consequences if a hydrogen-based energy economy is not properly managed," said Rahn. "No one foresaw what CFCs would do to the stratosphere when they were being developed. But now we have a chance to be proactive in saying what we need to consider when moving to a hydrogen economy."

Building on the Laboratory's expertise in hydrogen research, Manvendra Dubey, Rahn's colleague and mentor, is collaborating with the National Oceanic and Atmospheric Administration and the National Center for Atmospheric Research in applying models to study the effects of potential leakage during hydrogen production and transport.



Deuterium levels in stratospheric hydrogen (relative to seawater) versus mean age of air samples.

Dubey stressed, "It is extremely important to establish a global baseline of hydrogen and its budget in order to understand any changes in the future." Baseline measurements have proved critical to understanding global increases of carbon dioxide levels. Carbon dioxide measurements dating from the mid-1950s have shown an accelerating increase in the greenhouse gases produced from burning fossil fuels. "If we didn't have a carbon dioxide baseline, we would still be arguing whether the increase was due to human factors," Dubey said. Developing a hydrogen baseline will help the Department of Energy assess the varied options for guaranteeing the nation's energy security while managing the risks of global climate change.

—*James E. Rickman*